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# Group Report

1964-57

# Haystack Pointing System: Interpolation

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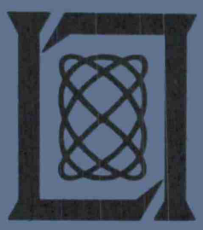
Lincoln Laboratory
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Lexington, Massachusetts



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MASSACHUSETTS INSTITUTE OF TECHNOLOGY

LINCOLN LABORATORY

# HAYSTACK POINTING SYSTEM: INTERPOLATION

*R. TEOSTE*

*Group 62*

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ABSTRACT

The Haystack antenna is pointed by means of a Univac 490 Computer. In the Pointing System program is incorporated an interpolation routine to provide pointing information 250 times a second. This report describes the interpolation routine.

Accepted for the Air Force
Stanley J. Wisniewski
Lt Colonel, USAF
Chief, Lincoln Laboratory Office

# HAYSTACK POINTING SYSTEM: INTERPOLATION

## INTRODUCTION

The Interpolation subroutine of the Haystack Pointing System is the last program to handle pointing information before it leaves the computer. The subroutine operates in the two second cycle of the Pointing System without any operator intervention. It interpolates for the required number of data points and converts the pointing information into proper format for the external equipment.

The Interpolation program accepts azimuth and elevation angles computed at two second intervals and interpolates 500 values of each at 4 millisecond intervals. The interpolation is handled so that dynamic servo error corrections can be added to the azimuth and elevation angles. The program computes doppler from range rate, makes a time correction for one-way transit time, and similarly interpolates to get 500 doppler values for every two second interval. Also the average range is computed for each two second interval.

## PROGRAM INPUTS

All program inputs are obtained from core storage. The following inputs are required:

| | |
|---|---|
| W(ACQAZIM) | B27 azimuth angle for $T_0$-2 sec (Revolutions) |
| W(ACQAZIM+1) | B27 azimuth angle for $T_0$ (Revolutions) |
| W(ACQAZIM+2) | B27 azimuth angle for $T_0$+2 sec (Revolutions) |
| W(ACQAZIM+3) | B27 azimuth angle for $T_0$+4 sec (Revolutions) |
| W(ACQELEV) | B27 elevation angle for $T_0$-2 sec (Revolutions) |
| W(ACQELEV+1) | B27 elevation angle for $T_0$ (Revolutions) |
| W(ACQELEV+2) | B27 elevation angle for $T_0$+2 sec (Revolutions) |
| W(ACQELEV+3) | B27 elevation angle for $T_0$+4 sec (Revolutions) |
| W(CRANGE) | B0 range for $T_0$+4 sec (.2 μsec of two-way range) |
| W(RANGEDOT) | B24 range rate for $T_0$+4 sec (nm/sec) |
| L(AZIMADD) | First location of azimuth 500 word buffer |
| L(ELEVADD) | First location of elevation 500 word buffer |
| L(RANGEADD) | Location of average range |

| | |
|---|---|
| L(DOPPADD) | First location of doppler 500 word buffer |
| L(RADARMODE) | Code for one- or two-way doppler |
| | + for two-way doppler |
| | - for one-way doppler |

PROGRAM OUTPUTS

The program outputs and the word formats are shown in TABLE I.

TABLE I

PROGRAM OUTPUTS

| | Azimuth | Elevation | Doppler | Range |
|---|---|---|---|---|
| Bit Positions | 0-19 | 0-18 | 0-20 | 0-24 |
| Binary Point | B19 | B19 | B0 | B0 |
| Units | Revolutions | Revolutions | CPS | .2 μsec of two-way range |
| Bias | 0 = North | 0 = Horizon | 0 = -750,000 | 0 = 0 |
| Range | 0-.999998 | 0-.999998 | -.75-+.75MC | 0-6.7 sec |
| Comments | A one in Bit Position 19 indicates overlap zone | Angles below horizon are represented by 360°-(angle) | | |
| No. of Words | 500 | 500 | 500 | 1 |
| First Word of Buffer Specified By | L(AZIMADD) | L(ELEVADD) | L(DOPPADD) | L(RANGEADD) |

INTERNAL OPERATION

Azimuth Interpolation

Let us designate four points of the desired antenna azimuth angle by $F_{-1}$, $F_0$, $F_1$, and $F_2$ for $T_0$ - 2 sec, $T_0$, $T_0$ + 2 sec and $T_0$ + 4 sec, respectively. The values of azimuth angles between $T_0$ and $T_0$ + 2 sec are to be interpolated. The interpolation is done in two parts: first, 25 equally-spaced points are interpolated between $F_0$ and $F_1$ by a four-point formula, and

then 9 points will be inserted between these interpolated points by linear interpolation.

The four-point formula, which will also insert a time shift and perform dynamic compensation, is of the form

$$F(y_k) = \sum_{i=-1}^{2} a_i (y_k) F_i \quad , \tag{1}$$

where

$$\begin{aligned}
a_{-1}(y_k) &= C_{-13}(y_k+\Delta)^3 + C_{-12}(y_k+\Delta)^2 + C_{-11}(y_k+\Delta) + C_{-10} \\
a_0(y_k) &= C_{03}(y_k+\Delta)^3 + C_{02}(y_k+\Delta)^2 + C_{01}(y_k+\Delta) + C_{00} \\
a_1(y_k) &= C_{13}(y_k+\Delta)^3 + C_{12}(y_k+\Delta)^2 + C_{11}(y_k+\Delta) + C_{10} \\
a_2(y_k) &= C_{23}(y_k+\Delta)^3 + C_{22}(y_k+\Delta)^2 + C_{21}(y_k+\Delta) + C_{20}
\end{aligned} \tag{2}$$

and

$C_{ij}$ are the interpolation coefficients

$h$ is the interval between computed points (2 seconds)

$y_k$ is the normalized time, $y_k = \frac{t_k - T_0}{h}$

$\Delta$ is the normalized desired time shift $\Delta = \frac{\text{time}}{h}$

The remaining points are computed by linear interpolation

$$F_\ell = \frac{\ell}{10} [F(y_{k+1}) - F(y_k)] + F(y_k) \quad , \tag{3}$$

where $\ell$ is an integer which ranges from zero to nine, and $F_\ell$ is the value of the desired function.

The errors due to these interpolation formulae are negligible as compared to the system error for typical expected target trajectories.

The basic quantities that do the work are $C_{ij}$ of Eq. (2). The values of the coefficients can be computed so that some of the dynamic servo error is eliminated. If no servo compensation is desired, the coefficients are

derived from a third-difference Bessel's interpolation formula.* The time delay $\Delta$ is added to take out the delays of the interface equipment and asynchronism of the computer and encoder systems.

TABLE II shows the interpolation coefficients and a correction term to each. The servo dynamic error is expected to be a linear combination of the antenna angular rates. The correction term of each coefficient in TABLE II adds a correction to the interpolated values of the form

$$E = K_0 F + K_1 \frac{dF}{dt} + K_2 \frac{d^2F}{dt^2} + K_3 \frac{d^3F}{dt^3} , \qquad (4)$$

where

E is in degrees

F is in degrees

$K_0$ is dimensionless

$K_1$ is in seconds

$K_2$ is in seconds$^2$

$K_3$ is in seconds$^3$.

While any correction that is of the form of Eq. (4) can be added, the values of $K_i$ are related to the servo error constants.+ The values of the constants will have to be measured experimentally.

ELEVATION INTERPOLATION

The elevation pointing angles are interpolated by the same method as the azimuth angles. Since the elevation servo response is expected to differ from the azimuth servo response, the values of the correction terms in the interpolation coefficients will be different.

RANGE

The average range for the interval between $T_0$ and $T_0$+ 2 sec is computed by

$$R_{avg} = \frac{1}{2} (R_0+R_1) \qquad (5)$$

*D. R. Hartree, "Numerical Analysis," (Oxford University Press, London, 1955), p. 68.

+J. G. Truxal, "Automatic Feedback Control System Synthesis," (McGraw-Hill, New York, 1955), p. 82.

TABLE II

INTERPOLATION COEFFICIENTS

| | Interpolation Coefficient | Correction Term |
|---|---|---|
| $C_{-13}$ | - 1/6 | $-\frac{K_0}{6}$ |
| $C_{-12}$ | 1/2 | $\frac{K_0}{2} - \frac{K_1}{4}$ |
| $C_{-11}$ | - 1/3 | $-\frac{K_0}{3} + \frac{K_1}{2} - \frac{K_2}{4}$ |
| $C_{-10}$ | 0 | $-\frac{K_1}{6} + \frac{K_2}{4} - \frac{K_3}{8}$ |
| $C_{03}$ | 1/2 | $\frac{K_0}{2}$ |
| $C_{02}$ | - 1 | $-K_0 + \frac{3K_1}{4}$ |
| $C_{01}$ | - 1/2 | $-\frac{K_0}{2} - K_1 + \frac{3K_2}{4}$ |
| $C_{00}$ | 1 | $K_0 - \frac{K_1}{4} - \frac{K_2}{2} + \frac{3K_3}{8}$ |
| $C_{13}$ | - 1/2 | $-\frac{K_0}{2}$ |
| $C_{12}$ | 1/2 | $\frac{K_0}{2} - \frac{3K_1}{4}$ |
| $C_{11}$ | 1 | $K_0 + \frac{K_1}{2} - \frac{3K_2}{4}$ |
| $C_{10}$ | 0 | $\frac{K_1}{2} + \frac{K_2}{4} - \frac{3K_3}{8}$ |
| $C_{23}$ | 1/6 | $\frac{K_0}{6}$ |
| $C_{22}$ | 0 | $\frac{K_1}{4}$ |
| $C_{21}$ | - 1/6 | $-\frac{K_0}{6} + \frac{K_2}{4}$ |
| $C_{20}$ | 0 | $-\frac{K_1}{12} + \frac{K_3}{8}$ |

Where $R_0$ is the computed range at $T_0$ and

$R_1$ is the computed range at $T_0$ + 2 sec.

DOPPLER INTERPOLATION

At main bang time, the radar receiver will request a doppler frequency. The frequency that it expects to get should correspond to the doppler shift due to the instantaneous range rate at the time the radar pulse hits the target. Hence, the doppler shift should be computed for one-way transit time later than when it is requested. Since the range is a slowly-varying function, and since the doppler shift is approximately a linear function of time, we can compute the one-way transit time and an average doppler rate and add their product to the doppler frequency at main bang time.

The one-way doppler shift is approximated by*

$$D = -\frac{\dot{R}}{C}\left(1 - \frac{\dot{R}}{C}\right) fo \quad , \tag{6}$$

where

D is the doppler shift (cps)

C is the speed of light (nm/sec)

fo is the transmitted frequency (cps)

$\dot{R}$ is the range rate (nm/sec)

When the one-way transit time is added into the calculations, Eq. (6) becomes

$$D_{\text{one-way}} = -\frac{fo}{C}\left[\dot{R}\left(1 - \frac{\dot{R}}{C}\right) + \frac{R}{C}\frac{d\dot{R}}{dt}\right] \cdot \tag{7}$$

---

*F. W. Sears and M. W. Zemansky, "College Physics," (Addison-Wesley, Cambridge, Massachusetts, 1952), p. 403.

The two-way doppler is twice Eq. (7), or

$$D_{\text{two-way}} = -\frac{2fo}{C}\left[\dot{R}\left(1-\frac{\dot{R}}{C}\right)+\frac{R}{C}\frac{d\dot{R}}{dt}\right] \quad . \qquad (8)$$

Four values of range rate are converted to doppler by Eq. (7) or (8) depending whether one-or two-way doppler was requested, and 250 points per second are interpolated as is done in the azimuth - elevation calculations by computing 25 points per second with the four-point formula and linearly interpolating for the remaining points. In the doppler interpolation, no dynamic compensation is required; thus, the coefficients $C_{ij}$ are given by the first column of TABLE II.

The interpolation formulae contribute no measurable errors in doppler shift.

PROGRAM DETAILS

The interpolations can be speeded up by working with the differences of the function values. This suggests the following transformation:

$$\begin{aligned} F(y) &= a_{-1}(y)F_{-1}+a_0(y)F_0+a_1(y)F_1+a_2(y)F_2 \\ &= a_{-1}(y)(F_{-1}-F_0)+a_1(y)(F_1-F_0)+a_2(F_2-F_0)+F_0. \end{aligned} \qquad (9)$$

Here only three multiplications are required instead of the four in the original form.

The program for computing this interpolation consists of two main parts - an initialization portion and an interpolation portion. The initialization portion is used while the Pointing System is being initialized and the interpolation portion is used in every two second cycle. Since the interpolation portion of the program has to run very fast, a lot of computations were done in the initialization portion of the program.

Figure 1 shows the flow chart of the initialization portion of the program. This portion of the program contains a subroutine (INITSUB) which computes the 51 values of $a_i(y)$. The subroutine requires that the starting

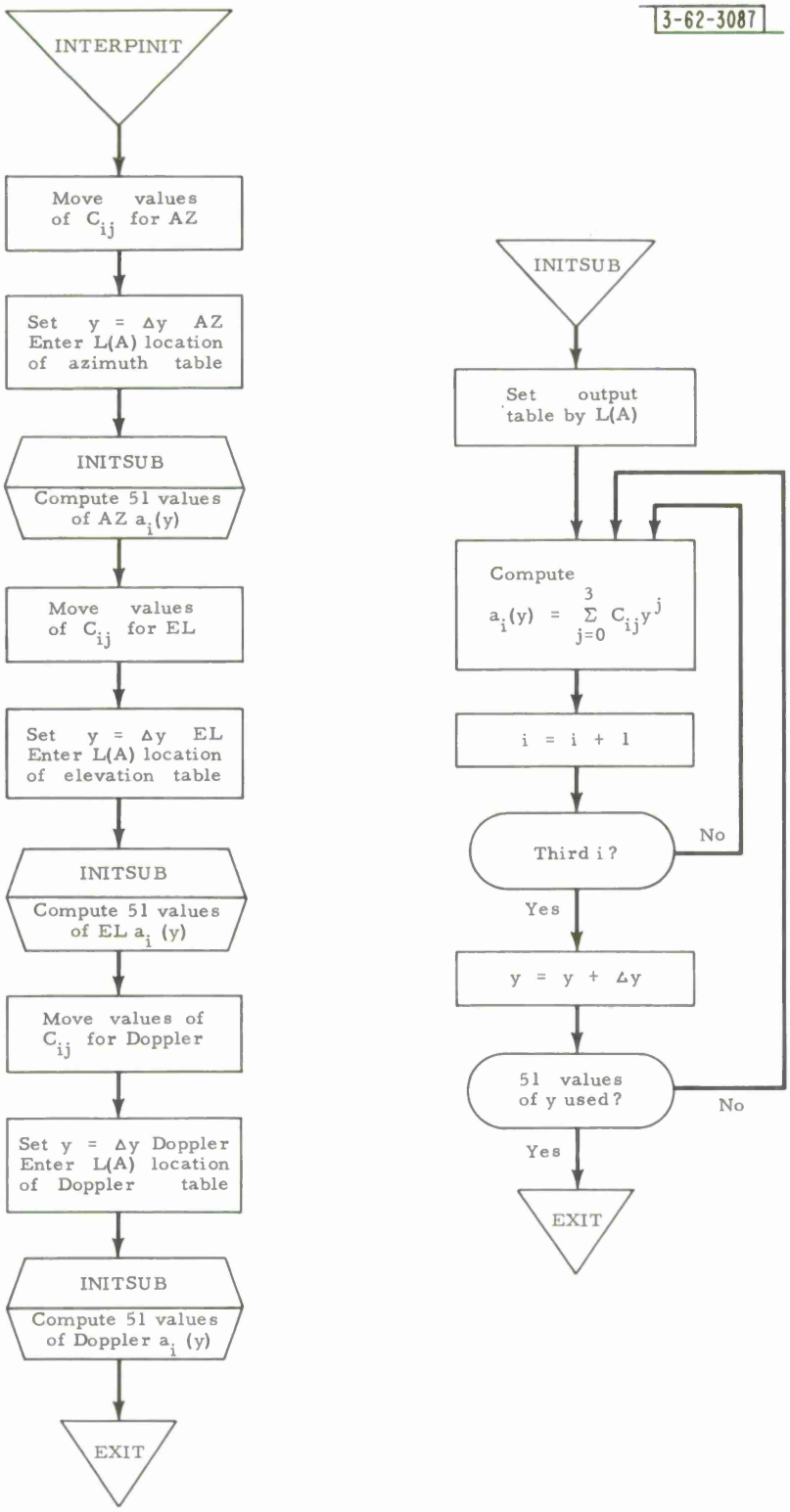


Fig. 1. Flow chart of the initialization portion of interpolation subroutine.

value of y be stored in core storage and the first location of the table for $a_i(y)$ be in the lower half of the A register. The order of the coefficients $a_i(y)$ which the subroutine computes is: $a_{-1}(y_1)$, $a_1(y_1)$, $a_2(y_1)$, $a_{-1}(y_2)$, $a_1(y_2)$, $a_2(y_2)$, etc. The control program which uses this subroutine simply moves the values of $C_{ij}$ into the location which the subroutine has set aside for them and sets the initial value of y to the timing delay associated with the particular variable. The control program does this for azimuth, elevation and doppler.

Since the initialization portion of the program is run only once during a pass, no effort was made to make the program fast. The required time for interpolation program initialization is a fraction of a second.

The interpolation portion of the program is flow charted in Fig. 2. It also contains a subroutine. The subroutine (INTSUB) interpolates 51 values of the function and fills in 9 points between these values by linear interpolation. The subroutine requires the values $(F_{-1} - F_0)$, $(F_1 - F_0)$, $(F_2 - F_0)$, and $F_0$. In addition, the location of the table of $a_i(y)$ and the location of the output buffer must be specified by index registers B4 and B5, respectively. The program which controls this subroutine (INTERP), supplies the values of $(F_{-1} - F_0)$, $(F_1 - F_0)$, $(F_2 - F_0)$, and $F_0$ to the subroutine and loads index registers B4 and B5 with proper table locations. The azimuth and elevation angles are compared to maximum and minimum limits and sent to the INTERP subroutine which computes the required pointing angles. The doppler values are first computed from range rate, and then the subroutine is used.

The interpolation portion of the interpolation routine was made as fast as possible. Some portions were coded several times in order to save time which is required for looping instructions. The running time of the interpolation portion of the program was measured to be 140 milliseconds for a particular test run. The timing will vary slightly for different input functions.

The complete listing of the interpolation program is given in the Appendix.

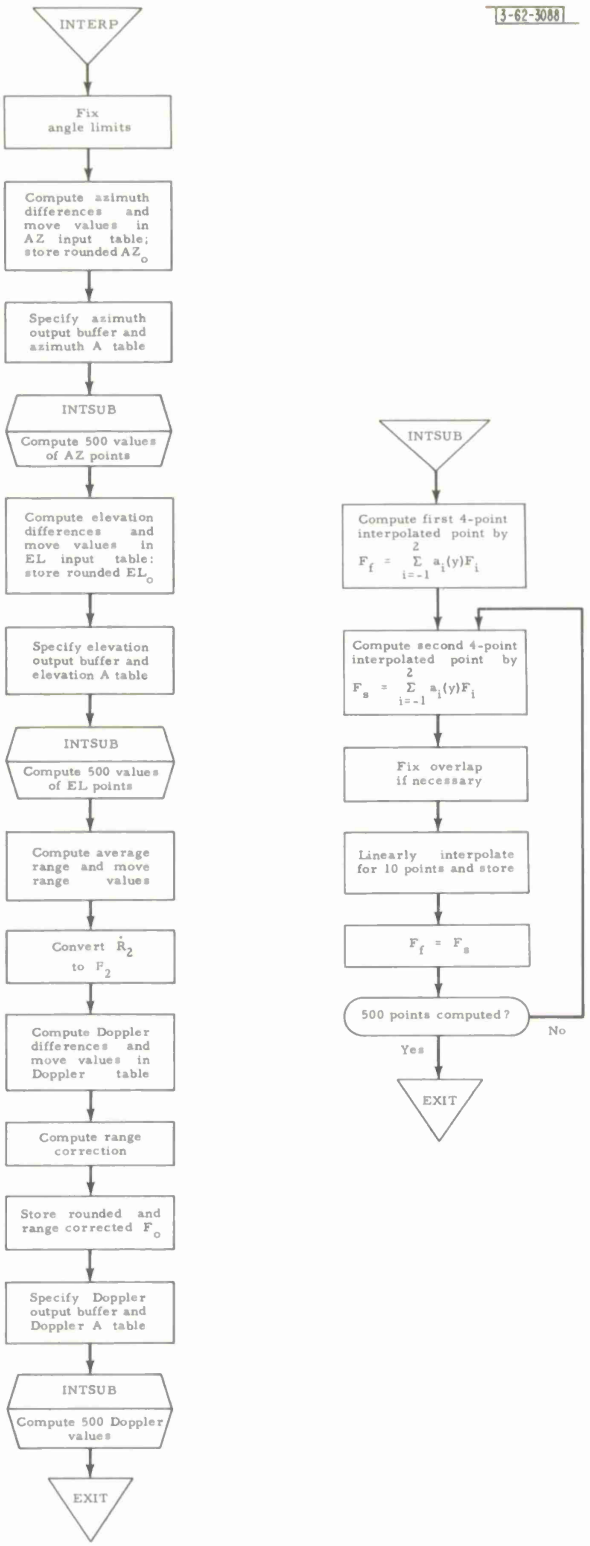


Fig. 2. Flow chart of the interpolation portion of subroutine.

Some of the variables one might want to change are:

| | | |
|---|---|---|
| W(DELAZ) | Azimuth timing delay | B27 in fractions of 2 sec interval (Present value in program is 1.806 m sec) |
| W(DELEL) | Elevation timing delay | B27 in fractions of 2 sec interval (Present value in program is 1.812 m sec) |
| W(DELDOP) | Doppler timing delay | B27 in fractions of 2 sec interval (Present value in program is 0) |
| W(CAZ) | Azimuth interpolation coefficients | B27 in the order $C_{20}, C_{21}, C_{22}, C_{23}, C_{10}, \ldots$ (Present values in program are the ones given in TABLE II column labeled interpolation coefficient) |
| W(CEL) | Elevation interpolation coefficients | B27 in the order $C_{20}, C_{21}, C_{22}, C_{23}, C_{10}, \ldots$ (Present values in program are the ones given in TABLE II column labeled interpolation coefficient) |
| W(CDOP) | Doppler interpolation coefficients | B27 in the order $C_{20}, C_{21}, C_{22}, C_{23}, C_{10}, \ldots$ (Present values in program are the ones given in TABLE II column labeled interpolation coefficient) |
| W(ELMIN) | Minimum allowable elevation | B27 in revolutions (Present value in program is $-1.8^{\circ}$) |
| W(ELMAX) | Maximum allowable elevation | B27 in revolutions (Present value in program is $90^{\circ}$) |
| W(AZMIN) | Minimum allowable azimuth | B27 in revolutions (Present value in program is $-115.2^{\circ}$) |
| W(AZMAX) | Maximum allowable azimuth | B27 in revolutions (Present value in program is $475.2^{\circ}$) |

..... SPURT OUTPUT NO. 211 .....

INTER TEOSTE•06/19/64

| LABEL | LOC | LABEL | LOC | LABEL | LOC |
|---|---|---|---|---|---|
| A$$$$$1111 | 00004 | A$$$$$1112 | 00010 | A$$$$$1113 | 00020 |
| A$$$$$1114 | 00024 | A$$$$$1115 | 00034 | A$$$$$1116 | 00040 |
| AAZ | 00214 | ACQAZIM | 63071 | ACQELEV | 63075 |
| ACQUI | 63427 | ACTUALTIME | 63142 | ADOP | 00676 |
| ADSCN | 63416 | AEL | 00445 | AESCN | 63417 |
| ASTRODEC | 63106 | ASTRORA | 63105 | AUCONVER | 63332 |
| AUPEREQUAT | 63341 | AZ | 63071 | AZIM | 63053 |
| AZIMOUT | 64000 | AZIMOVER | 63325 | AZIMADD | 63442 |
| AZIMIN | 75000 | AZMAX | 01332 | AZMIN | 01331 |
| BOUNCE | 01310 | BIAS | 01335 | BLASTOFF | 63146 |
| COCON | 63414 | CONST | 00065 | CONVERSION | 00061 |
| CONVERTIME | 63135 | CORCT | 63420 | COSORIENT | 63065 |
| COSAZEL | 63070 | CAZ | 00106 | CAZIM | 63060 |
| CDOP | 00126 | CEL | 00066 | CELBODY | 63113 |
| CELCOMPGM | 63424 | CELEV | 63061 | CELTIME | 63133 |
| CHCOR | 63422 | CHPAR | 63431 | CRANGE | 63057 |
| DOPPOUT | 66000 | DOPPADD | 63444 | DATANALYZE | 63425 |
| DAY | 63150 | DEC | 63003 | DECDOT | 63010 |
| DELAZ | 00062 | DELDOP | 00064 | DELEL | 00063 |
| DELTATEE | 63316 | DELY | 00177 | DSECONDS | 63141 |
| DUMSECTTG | 63154 | DYDMP | 63421 | EL | 63075 |
| ELEV | 63054 | ELEVOUT | 65000 | ELEVADD | 63443 |
| ELEVIN | 76000 | ELMAX | 01330 | ELMIN | 01327 |
| ENDAZ | 01135 | ENDAZBOUNC | 01142 | ENDEL | 01150 |
| EQUATUR | 63323 | ESTSHIFTED | 63143 | EXPNAME | 63350 |
| F | 00210 | FIRST | 00201 | FIRSTELEV | 63104 |
| FIRSTHRU | 63153 | FLATTENING | 63337 | FRAMESIZE | 63101 |
| FREQUENCY | 63317 | GEOCENLAT | 63322 | GEODETLAT | 63321 |
| GMTMODU24 | 63145 | GMTSHIFTED | 63144 | HOURMINUTE | 63137 |
| HOURREG | 63151 | HEIGHT | 63326 | ID10RADIO | 66777 |
| ID11RADIO | 67776 | ID12RADIO | 67777 | ID13RADIO | 70775 |
| ID14RADIO | 70776 | ID15RADIO | 71776 | ID16RADIO | 71777 |
| ID17RADIO | 72776 | ID18RADIO | 72777 | ID19RADIO | 73776 |
| ID1CELCOR | 63000 | ID1ENTPNT | 63410 | ID1RADCOR | 63050 |
| ID1RADIO | 63440 | ID1RECRD | 63210 | ID1SYSENT | 77576 |
| ID1SYSNAM | 77676 | ID1SYSPAR | 63310 | ID1TIME | 63130 |
| ID20RADIO | 73777 | ID21RADIO | 74776 | ID22RADIO | 74777 |
| ID23RADIO | 75776 | ID24RADIO | 75777 | ID25RADIO | 76775 |
| ID26RADIO | 76776 | ID2CELCOR | 63001 | ID2ENTPNT | 63411 |
| ID2RADCOR | 63051 | ID2RADIO | 63441 | ID2RECRD | 63211 |
| ID2SYSENT | 77577 | ID2SYSNAM | 77677 | ID2SYSPAR | 63311 |
| ID2TIME | 63131 | ID3RADIO | 63776 | ID4RADIO | 63777 |
| ID5RADIO | 64776 | ID6RADIO | 64777 | ID7RADIO | 65776 |
| ID8RADIO | 65777 | ID9RADIO | 66776 | INAZIMADD | 63446 |
| INELEVADD | 63447 | INITSUB | 00146 | INTER | 63413 |
| INTERAZIM | 72000 | INTERCOM | 63426 | INTERDOPP | 74000 |
| INTERELEV | 73000 | INTERP | 01127 | INTERPINIT | 00002 |
| INTERRANGE | 76777 | INTERY | 00000 | INTSUBR | 01336 |
| JUNK | 00200 | KMPERNM | 63342 | KYBRDLEVEL | 63110 |
| LONGITUDE | 63320 | LAP | 01326 | LSPERAU | 63336 |
| MAINSWITCH | 63334 | MCPFILLER | 71000 | MCPGM | 63412 |

..... SPURT OUTPUT NO. 211 .....

INTER TEOSTE•06/19/64

| LABEL | LOC | LABEL | LOC | LABEL | LOC |
|---|---|---|---|---|---|
| MINREG | 63152 | NMPERAU | 63340 | POLE | 63324 |
| PLANP | 63434 | PRLOG | 63423 | R | 01460 |
| R1 | 00151 | R2 | 00153 | R3 | 00157 |
| R4 | 00164 | R5 | 01356 | RA | 63002 |
| RADOT | 63007 | RADARMODE | 63312 | RADIOMETER | 63102 |
| RADIUS | 63006 | RADIUSDOT | 63011 | RANGE | 63052 |
| RANGEOUT | 70777 | RANGEADD | 63445 | RANGEDOT | 63062 |
| RANGEUNIT | 01334 | RDOT | 01463 | RDMTR | 63430 |
| RDXXX | 63433 | RECORDSIZE | 63112 | RECAZIM | 67000 |
| RECC | 00057 | RECELEV | 70000 | RECFILE | 63212 |
| RECRD | 63415 | REVOLUTION | 01333 | SAZIM | 63055 |
| SCELTIME | 63134 | SDEC | 63005 | SECOND | 00202 |
| SECONDS | 63140 | SELEV | 63056 | SIDERTIME | 63012 |
| SINORIENT | 63064 | SINAZEL | 63066 | SKIP | 63331 |
| SRA | 63004 | SRADTIME | 63136 | STARTAZ | 01130 |
| STARTEL | 01143 | SYSENTRIES | 77600 | SYSNAMES | 77700 |
| SYSTAT1 | 63313 | SYSTAT2 | 63314 | SYSTATD | 63315 |
| TENTH | 01457 | TEST1 | 01303 | TEST2 | 01311 |
| TEST3 | 01315 | TEST5 | 01322 | TIMECORR | 63107 |
| TIMEMODE | 63103 | TIMEP | 63435 | TRUERANGE | 63063 |
| TRUETIME | 63132 | TTYSTATUS | 63111 | UKS | 00056 |
| VELOFLIGHT | 63335 | VIZDEC1 | 63014 | VIZDEC2 | 63016 |
| VIZRA1 | 63013 | VIZRA2 | 63015 | WFORD | 63432 |
| WFADD | 63450 | WFFREQ | 63333 | Y | 00060 |
| YEARMONTH | 63147 | YRTRAN | 63327 | ZRTRAN | 63330 |

END OF LISTING

..... SPURT OUTPUT NO. 212 .....

INTER TEOSTE*06/19/64

| LABEL | LOC | LABEL | LOC | LABEL | LOC |
|---|---|---|---|---|---|
| INTERY | 00000 | INTERPINIT | 00002 | A$$$$$1111 | 00004 |
| A$$$$$1112 | 00010 | A$$$$$1113 | 00020 | A$$$$$1114 | 00024 |
| A$$$$$1115 | 00034 | A$$$$$1116 | 00040 | UKS | 00056 |
| RECC | 00057 | Y | 00060 | CONVERSION | 00061 |
| DELAZ | 00062 | DELEL | 00063 | DELDOP | 00064 |
| CONST | 00065 | CEL | 00066 | CAZ | 00106 |
| CDOP | 00126 | INITSUB | 00146 | R1 | 00151 |
| R2 | 00153 | R3 | 00157 | R4 | 00164 |
| DELY | 00177 | JUNK | 00200 | FIRST | 00201 |
| SECOND | 00202 | F | 00210 | AAZ | 00214 |
| AEL | 00445 | ADOP | 00676 | INTERP | 01127 |
| STARTAZ | 01130 | ENDAZ | 01135 | ENDAZBOUNC | 01142 |
| STARTEL | 01143 | ENDEL | 01150 | TEST1 | 01303 |
| BOUNCE | 01310 | TEST2 | 01311 | TEST3 | 01315 |
| TEST5 | 01322 | LAP | 01326 | ELMIN | 01327 |
| ELMAX | 01330 | AZMIN | 01331 | AZMAX | 01332 |
| REVOLUTION | 01333 | RANGEUNIT | 01334 | BIAS | 01335 |
| INTSUBR | 01336 | R5 | 01356 | TENTH | 01457 |
| R | 01460 | RDOT | 01463 | ID1CELCOR | 63000 |
| ID2CELCOR | 63001 | RA | 63002 | DEC | 63003 |
| SRA | 63004 | SDEC | 63005 | RADIUS | 63006 |
| RADOT | 63007 | DECDOT | 63010 | RADIUSDOT | 63011 |
| SIDERTIME | 63012 | VIZRA1 | 63013 | VIZDEC1 | 63014 |
| VIZRA2 | 63015 | VIZDEC2 | 63016 | ID1RADCOR | 63050 |
| ID2RADCOR | 63051 | RANGE | 63052 | AZIM | 63053 |
| ELEV | 63054 | SAZIM | 63055 | SELEV | 63056 |
| CRANGE | 63057 | CAZIM | 63060 | CELEV | 63061 |
| RANGEDOT | 63062 | TRUERANGE | 63063 | SINORIENT | 63064 |
| COSORIENT | 63065 | SINAZEL | 63066 | COSAZEL | 63070 |
| ACQAZIM | 63071 | AZ | 63071 | ACQELEV | 63075 |
| EL | 63075 | FRAMESIZE | 63101 | RADIOMETER | 63102 |
| TIMEMODE | 63103 | FIRSTELEV | 63104 | ASTRORA | 63105 |
| ASTRODEC | 63106 | TIMECORR | 63107 | KYBRDLEVEL | 63110 |
| TTYSTATUS | 63111 | RECORDSIZE | 63112 | CELBODY | 63113 |
| ID1TIME | 63130 | ID2TIME | 63131 | TRUETIME | 63132 |
| CELTIME | 63133 | SCELTIME | 63134 | CONVERTIME | 63135 |
| SRADTIME | 63136 | HOURMINUTE | 63137 | SECONDS | 63140 |
| DSECONDS | 63141 | ACTUALTIME | 63142 | ESTSHIFTED | 63143 |
| GMTSHIFTED | 63144 | GMTMODU24 | 63145 | BLASTOFF | 63146 |
| YEARMONTH | 63147 | DAY | 63150 | HOURREG | 63151 |
| MINREG | 63152 | FIRSTHRU | 63153 | DUMSECTTG | 63154 |
| ID1RECRD | 63210 | ID2RECRD | 63211 | RECFILE | 63212 |
| ID1SYSPAR | 63310 | ID2SYSPAR | 63311 | RADARMODE | 63312 |
| SYSTAT1 | 63313 | SYSTAT2 | 63314 | SYSTATD | 63315 |
| DELTATEE | 63316 | FREQUENCY | 63317 | LONGITUDE | 63320 |
| GEODETLAT | 63321 | GEOCENLAT | 63322 | EQUATOR | 63323 |
| POLE | 63324 | AZIMOVER | 63325 | HEIGHT | 63326 |
| YRTRAN | 63327 | ZRTRAN | 63330 | SKIP | 63331 |
| AUCONVER | 63332 | WFFREQ | 63333 | MAINSWITCH | 63334 |
| VELOFLIGHT | 63335 | LSPERAU | 63336 | FLATTENING | 63337 |
| NMPERAU | 63340 | AUPEREQUAT | 63341 | KMPERNM | 63342 |

..... SPURT OUTPUT NO. 212 .....

INTER TEOSTE•06/19/64

| LABEL | LOC | LABEL | LOC | LABEL | LOC |
|---|---|---|---|---|---|
| EXPNAME | 63350 | ID1ENTPNT | 63410 | ID2ENTPNT | 63411 |
| MCPGM | 63412 | INTER | 63413 | COCON | 63414 |
| RECRD | 63415 | ADSCN | 63416 | AESCN | 63417 |
| CORCT | 63420 | DYDMP | 63421 | CHCOR | 63422 |
| PRLOG | 63423 | CELCOMPGM | 63424 | DATANALYZE | 63425 |
| INTERCOM | 63426 | ACQUI | 63427 | RDMTR | 63430 |
| CHPAR | 63431 | WFORD | 63432 | RDXXX | 63433 |
| PLANP | 63434 | TIMEP | 63435 | ID1RADIO | 63440 |
| ID2RADIO | 63441 | AZIMADD | 63442 | ELEVADD | 63443 |
| DOPPADD | 63444 | RANGEADD | 63445 | INAZIMADD | 63446 |
| INELEVADD | 63447 | WFADD | 63450 | ID3RADIO | 63776 |
| ID4RADIO | 63777 | AZIMOUT | 64000 | ID5RADIO | 64776 |
| ID6RADIO | 64777 | ELEVOUT | 65000 | ID7RADIO | 65776 |
| ID8RADIO | 65777 | DOPPOUT | 66000 | ID9RADIO | 66776 |
| ID10RADIO | 66777 | RECAZIM | 67000 | ID11RADIO | 67776 |
| ID12RADIO | 67777 | RECELEV | 70000 | ID13RADIO | 70775 |
| ID14RADIO | 70776 | RANGEOUT | 70777 | MCPFILLER | 71000 |
| ID15RADIO | 71776 | ID16RADIO | 71777 | INTERAZIM | 72000 |
| ID17RADIO | 72776 | ID18RADIO | 72777 | INTERELEV | 73000 |
| ID19RADIO | 73776 | ID20RADIO | 73777 | INTERDOPP | 74000 |
| ID21RADIO | 74776 | ID22RADIO | 74777 | AZIMIN | 75000 |
| ID23RADIO | 75776 | ID24RADIO | 75777 | ELEVIN | 76000 |
| ID25RADIO | 76775 | ID26RADIO | 76776 | INTERRANGE | 76777 |
| ID1SYSENT | 77576 | ID2SYSENT | 77577 | SYSENTRIES | 77600 |
| ID1SYSNAM | 77676 | ID2SYSNAM | 77677 | SYSNAMES | 77700 |

END OF LISTING

..... SPURT OUTPUT NO. 210 .....

INTER TEOSTE*06/19/64

NO. OF INSTRUCTIONS 01467

| | | |
|---|---|---|
| 00000 | THRU | 00200 |
| 00214 | THRU | 00214 |
| 00445 | THRU | 00445 |
| 00676 | THRU | 00676 |
| 01127 | THRU | 01460 |
| 01463 | THRU | 01463 |
| 01466 | THRU | 01466 |

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CARDS    L1 ID LABEL      TA STATEMENT                              LOC    F JKB Y      NOTES

    .    00000 INTER          PROGRAM   TEOSTE*06/19/64
    .    00001 INTERY         U-TAG     INTERP*INTERPINIT           00000  01127 00002
    .    00002                FD   1*INTER                          00001  16233 11227
    .    00003 INTERPINIT     ENTRY                                 00002  61000 00000
    .    00004                MOVE 8D*CAZ*JUNK                      00003  12700 00007  MOVE VALUES OF AAZ
                                                                    00004  10037 00106
                                                                    00005  14037 00200
                                                                    00006  72700 00004
    .    00005                MOVE 4*CAZ+12D*JUNK+8D                00007  12700 00003
                                                                    00010  10037 00122
                                                                    00011  14037 00210
                                                                    00012  72700 00010
    .    00006                MOVE 1*DELAZ*Y                        00013  10030 00062  DELAZ EQUALS Y
                                                                    00014  14030 00060
    .    00007                ENT  A*AAZ                            00015  11000 00214  OUTPUT TABLE IN AAZ
    .    00010                RJP  INITSUB                          00016  65000 00146  COMPUTE AZIMUTH TABLE
    .    00011                MOVE 8D*CEL*JUNK                      00017  12700 00007  MOVE VALUES OF CEL
                                                                    00020  10037 00066
                                                                    00021  14037 00200
                                                                    00022  72700 00020
    .    00012                MOVE 4*CEL+12D*JUNK+8D                00023  12700 00003
                                                                    00024  10037 00102
                                                                    00025  14037 00210
                                                                    00026  72700 00024
    .    00013                MOVE 1*DELEL*Y                        00027  10030 00063  DELEL EQUALS Y
                                                                    00030  14030 00060
    .    00014                ENT  A*AEL                            00031  11000 00445  OUTPUT TABLE IN AEL
    .    00015                RJP  INITSUB                          00032  65000 00146  COMPUTE ELEVATION TABLE
    .    00016                MOVE 8D*CDOP*JUNK                     00033  12700 00007  MOVE VALUES OF CDOP
                                                                    00034  10037 00126
                                                                    00035  14037 00200
                                                                    00036  72700 00034
    .    00017                MOVE 4*CDOP+12D*JUNK+8D               00037  12700 00003
                                                                    00040  10037 00142
                                                                    00041  14037 00210
                                                                    00042  72700 00040
    .    00020                MOVE 1*DELDOP*Y                       00043  10030 00064  DELDOP = Y
                                                                    00044  14030 00060
    .    00021                ENT  A*ADOP                           00045  11000 00676  OUTPUT TABLE IN ADOP
    .    00022                RJP  INITSUB                          00046  65000 00146  COMPUTE DOPPLER TABLE
    .    00023                ENT  Q*W(CONST)                       00047  10030 00065
    .    00024                ENT  A*LX(RADARMODE)*APOS             00050  11650 63312  CODE IS PLUS FOR 2-WAY DOPPLER

    .    00025                RSH  Q*1                              00051  01000 00001
    .    00026                MUL  W(FREQUENCY)                     00052  22030 63317
    .    00027                RSH  AQ*28D                           00053  03000 00034  810
    .    00030                STR  Q*W(CONVERSION)                  00054  14030 00061  CONVERSION CONSTANT 2F/C OR F/
                                                                                        C
    .    00031                EXIT                                  00055  61010 00002
    .    00032 UKS            0100000000                            00056  01000 00000  DEC        1824

    .    00033 RECC           0000014757                            00057  00000 14757  DEC .000006182830
    .    00034 Y              0                                     00060  00000 00000
```

| CARDS | L1 | ID | LABEL | TA | STATEMENT | LOC | F | JKB | Y | NOTES |
|---|---|---|---|---|---|---|---|---|---|---|
| . | 00035 | | CONVERSION | | RESERVE 1 | 00061 | 00000 | 00000 | | |
| . | 00036 | | DELAZ | | 0000354556 | 00062 | 00003 | 54556 | | DEC .000903B27 AZIMUTH TIMING DELAY |
| . | 00037 | | DELEL | | 0000355401 | 00063 | 00003 | 55401 | | DEC .000906B27 ELEVATION TIMING DELAY |
| . | 00040 | | DELDOP | | 0000000000 | 00064 | 00000 | 00000 | | DEC 0.0B27 DOPPLER TIMING DELAY |
| . | 00041 | | CONST | | 1427243740 | 00065 | 14272 | 43740 | | DEC 12.364378B24 2/C E-6 |
| . | 00042 | | CEL | | 0000000000 | 00066 | 00000 | 00000 | | DEC 0.0B27 EVELATION INTERPOLATION COEFFIC |
| . | 00043 | | | | 7652525252 | 00067 | 76525 | 25252 | | DEC -.16666667B27 |
| . | 00044 | | | | 0000000000 | 00070 | 00000 | 00000 | | DEC 0B27 |
| . | 00045 | | | | 0125252525 | 00071 | 01252 | 52525 | | DEC .16666667B27 |
| . | 00046 | | | | 0000000000 | 00072 | 00000 | 00000 | | DEC 0B27 |
| . | 00047 | | | | 1000000000 | 00073 | 10000 | 00000 | | DEC 1B27 |
| . | 00050 | | | | 0400000000 | 00074 | 04000 | 00000 | | DEC .5B27 |
| . | 00051 | | | | 7377777777 | 00075 | 73777 | 77777 | | DEC -.5B27 |
| . | 00052 | | | | 1000000000 | 00076 | 10000 | 00000 | | DEC 1B27 |
| . | 00053 | | | | 7377777777 | 00077 | 73777 | 77777 | | DEC -.5B27 |
| . | 00054 | | | | 6777777777 | 00100 | 67777 | 77777 | | DEC -1B27 |
| . | 00055 | | | | 0400000000 | 00101 | 04000 | 00000 | | DEC .5B27 |
| . | 00056 | | | | 0000000000 | 00102 | 00000 | 00000 | | DEC 0B27 |
| . | 00057 | | | | 7525252525 | 00103 | 75252 | 52525 | | DEC -.33333333B27 |
| . | 00060 | | | | 0400000000 | 00104 | 04000 | 00000 | | DEC .5B27 |
| . | 00061 | | | | 7652525252 | 00105 | 76525 | 25252 | | DEC -.16666667B27 |
| . | 00062 | | CAZ | | 0000000000 | 00106 | 00000 | 00000 | | DEC 0.0B27 AZIMUTH INTERPOLATION COEFFICIE |
| . | 00063 | | | | 7652525252 | 00107 | 76525 | 25252 | | DEC -.16666667B27 |
| . | 00064 | | | | 0000000000 | 00110 | 00000 | 00000 | | DEC 0B27 |
| . | 00065 | | | | 0125252525 | 00111 | 01252 | 52525 | | DEC .16666667B27 |
| . | 00066 | | | | 0000000000 | 00112 | 00000 | 00000 | | DEC 0B27 |
| . | 00067 | | | | 1000000000 | 00113 | 10000 | 00000 | | DEC 1B27 |

| CARDS | LI ID LABEL | INTER TA STATEMENT | LOC | F JKB Y | NOTES | |
|---|---|---|---|---|---|---|
| . | 00070 | 0400000000 | 00114 | 04000 00000 | DEC | .5B27 |
| . | 00071 | 7377777777 | 00115 | 73777 77777 | DEC | -.5B27 |
| . | 00072 | 1000000000 | 00116 | 10000 00000 | DEC | 1B27 |
| . | 00073 | 7377777777 | 00117 | 73777 77777 | DEC | -.5B27 |
| . | 00074 | 6777777777 | 00120 | 67777 77777 | DEC | -1B27 |
| . | 00075 | 0400000000 | 00121 | 04000 00000 | DEC | .5B27 |
| . | 00076 | 0000000000 | 00122 | 00000 0000C | DEC | 0B27 |
| . | 00077 | 7525252525 | 00123 | 75252 52525 | DEC | -.33333333B27 |
| . | 00100 | 0400000000 | 00124 | 04000 0000C | DEC | .5B27 |
| . | 00101 | 7652525252 | 00125 | 76525 25252 | DEC | -.16666667B27 |
| . | 00102 CDOP | 0000000000 | 00126 | 00000 00000 | DEC | 0.0B27 DOPPLER INT ERPOLATION COEFFICIE |
| . | 00103 | 7652525252 | 00127 | 76525 25252 | DEC | -.16666667B27 |
| . | 00104 | 0000000000 | 00130 | 00000 0000C | DEC | 0B27 |
| . | 00105 | 0125252525 | 00131 | 01252 52525 | DEC | .16666667B27 |
| . | 00106 | 0000000000 | 00132 | 00000 0000C | DEC | 0B27 |
| . | 00107 | 1000000000 | 00133 | 10000 00000 | DEC | 1B27 |
| . | 00110 | 0400000000 | 00134 | 04000 0000C | DEC | .5B27 |
| . | 00111 | 7377777777 | 00135 | 73777 77777 | DEC | -.5B27 |
| . | 00112 | 1000000000 | 00136 | 10000 0000C | DEC | 1B27 |
| . | 00113 | 7377777777 | 00137 | 73777 77777 | DEC | -.5B27 |
| . | 00114 | 6777777777 | 00140 | 67777 77777 | DEC | -1B27 |
| . | 00115 | 0400000000 | 00141 | 04000 00000 | DEC | .5B27 |
| . | 00116 | 0000000000 | 00142 | 00000 0000C | DEC | 0B27 |
| . | 00117 | 7525252525 | 00143 | 75252 52525 | DEC | -.33333333B27 |
| . | 00120 | 0400000000 | 00144 | 04000 0000C | DEC | .5B27 |
| . | 00121 | 7652525252 | 00145 | 76525 25252 | DEC | -.16666667B27 |
| . | 00122 INITSUB | ENTRY | 00146 | 61000 0000C | LOCATION OF OUTPUT TABLE IN LI | |

| CARDS | L1 | ID | LABEL | TA | STATEMENT | LOC | F | JKB | Y | NOTES |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | A) |
| . | 00123 | | | | STR A*L(R4) | 00147 | 15 | 010 | 00164 | |
| . | 00124 | | | | ENT B5*50D | 00150 | 12 | 500 | 00062 | |
| . | 00125 | R1 | | | ENT B6*2 | 00151 | 12 | 600 | 00002 | |
| . | 00126 | | | | ENT A*JUNK+3 | 00152 | 11 | 000 | 00203 | |
| . | 00127 | R2 | | | STR A*L(R3) | 00153 | 15 | 010 | 00157 | |
| . | 00130 | | | | SUB A*3 | 00154 | 21 | 000 | 00003 | |
| . | 00131 | | | | STR A*L(R3+3) | 00155 | 15 | 010 | 00162 | |
| . | 00132 | | | | ENT B7*2 | 00156 | 12 | 700 | 00002 | |
| . | 00133 | R3 | | | ENT Q*W(000) | 00157 | 10 | 030 | 00000 | SET TO JUNK+3 |
| . | 00134 | | | | MUL W(Y) | 00160 | 22 | 030 | 00060 | |
| . | 00135 | | | | RSH AQ*27D | 00161 | 03 | 000 | 00033 | |
| . | 00136 | | | | ADD Q*W(B7) | 00162 | 26 | 037 | 00000 | SET TO JUNK |
| . | 00137 | | | | BJP B7*R3+1 | 00163 | 72 | 700 | 00160 | ONE VALUE OF A COMPUTED |
| . | 00140 | R4 | | | STR Q*W(B6) | 00164 | 14 | 036 | 00000 | SET TO OUTPUT TABLE |
| . | 00141 | | | | ENT A*4 | 00165 | 11 | 000 | 00004 | |
| . | 00142 | | | | ADD A*L(R3) | 00166 | 20 | 010 | 00157 | |
| . | 00143 | | | | BJP B6*R2 | 00167 | 72 | 600 | 00153 | THREE VALUES OF A COMPUTED |
| . | 00144 | | | | ENT Q*3 | 00170 | 10 | 000 | 00003 | |
| . | 00145 | | | | RPL Y+Q*L(R4) | 00171 | 34 | 010 | 00164 | |
| . | 00146 | | | | ENT A*W(Y) | 00172 | 11 | 030 | 00060 | COMPUTE NEW VALUE OF Y |
| . | 00147 | | | | ADD A*W(DELY) | 00173 | 20 | 030 | 00177 | |
| . | 00150 | | | | STR A*W(Y) | 00174 | 15 | 030 | 00060 | |
| . | 00151 | | | | BJP B5*R1 | 00175 | 72 | 500 | 00151 | 51 VALUES OF Y USED |
| . | 00152 | | | | EXIT | 00176 | 61 | 010 | 00146 | |
| . | 00153 | | DELY | | 0012172702 | 00177 | 00 | 121 | 72702 | DEC .02827 INCREMENT O F Y |
| . | 00154 | | JUNK | | RESERVE 12D | 00200 | 00000 | | 00000 | |
| . | 00155 | | AZ | | EQUALS ACQAZIM | | | | | |
| . | 00156 | | EL | | EQUALS ACQELEV | | | | | |
| . | 00157 | | F | | EQUALS JUNK+8D | | | | | |
| . | 00160 | | FIRST | | EQUALS JUNK+1 | | | | | |
| . | 00161 | | SECOND | | EQUALS JUNK+2 | | | | | |
| . | 00162 | | AAZ | | RESERVE 153D | 00214 | 00000 | | 00000 | |
| . | 00163 | | AEL | | RESERVE 153D | 00445 | 00000 | | 00000 | |
| . | 00164 | | ADOP | | RESERVE 153D | 00676 | 00000 | | 00000 | |
| . | 00165 | | INTERP | | ENTRY | 01127 | 61 | 000 | 00000 | |
| . | 00166 | | STARTAZ | | ENT A*W(AZ+3)*APOS | 01130 | 11 | 630 | 63074 | AZIMUTH LIMITS |
| . | 00167 | | | | JP TEST2 | 01131 | 61 | 000 | 01311 | |
| . | 00170 | | | | SUB A*W(AZMAX)*APOS | 01132 | 21 | 630 | 01332 | |
| . | 00171 | | | | JP ENDAZ+1 | 01133 | 61 | 000 | 01136 | |
| . | 00172 | | | | ENT A*W(AZMAX) | 01134 | 11 | 030 | 01332 | |
| . | 00173 | | ENDAZ | | STR A*W(AZ+3) | 01135 | 15 | 030 | 63074 | |
| . | 00174 | | | | ENT A*W(AZ+3) | 01136 | 11 | 030 | 63074 | OVERSHOOT CORRECTION |
| . | 00175 | | | | SUB A*W(AZ+2)*APOS | 01137 | 21 | 630 | 63073 | |
| . | 00176 | | | | STR A*A | 01140 | 15 | 040 | 00000 | |
| . | 00177 | | | | SUB A*W(BOUNCE)*ANEG | 01141 | 21 | 730 | 01310 | |
| . | 00200 | | ENDAZBOUNC | | JP TEST3 | 01142 | 61 | 000 | 01315 | |
| . | 00201 | | STARTEL | | ENT A*W(EL+3)*APOS | 01143 | 11 | 630 | 63100 | ELEVATION LIMITS |
| . | 00202 | | | | JP TEST5 | 01144 | 61 | 000 | 01322 | |
| . | 00203 | | | | SUB A*W(ELMAX)*ANEG | 01145 | 21 | 730 | 01330 | |
| . | 00204 | | | | ENT A*W(ELMAX)*SKIP | 01146 | 11 | 130 | 01330 | |
| . | 00205 | | | | ENT A*W(EL+3) | 01147 | 11 | 030 | 63100 | |

| CARDS | L1 ID | LABEL | TA | STATEMENT | LOC | F JKB Y | NOTES |
|---|---|---|---|---|---|---|---|
| . | 00206 | ENDEL | STR | A•W(EL+3) | 01150 | 15030 63100 | |
| . | 00207 | | SUB | A•W(EL+2)•APOS | 01151 | 21630 63077 | |
| . | 00210 | | STR | A•A | 01152 | 15040 00000 | |
| . | 00211 | | SUB | A•W(BOUNCE)•ANEG | 01153 | 21730 01310 | |
| . | 00212 | | JP | TEST1 | 01154 | 61000 01303 | |
| . | 00213 | | ENT | A•W(AZ) | 01155 | 11030 63071 | |
| . | 00214 | | SUB | A•W(AZ+1) | 01156 | 21030 63072 | |
| . | 00215 | | STR | A•W(F) | 01157 | 15030 00210 | STORE DIFFERENCE OF AZ0 |
| . | 00216 | | ENT | A•W(AZ+1) | 01160 | 11030 63072 | |
| . | 00217 | | STR | A•W(AZ)•APOS | 01161 | 15630 63071 | |
| . | 00220 | | SUB | A•200•SKIP | 01162 | 21100 00200 | |
| . | 00221 | | ADD | A•200 | 01163 | 20000 00200 | |
| . | 00222 | | STR | A•W(F+3) | 01164 | 15030 00213 | STORE ROUNDED AZ1 |
| . | 00223 | | ENT | A•W(AZ+2) | 01165 | 11030 63073 | |
| . | 00224 | | STR | A•W(AZ+1) | 01166 | 15030 63072 | MOVE AZ2 |
| . | 00225 | | SUB | A•W(AZ) | 01167 | 21030 63071 | |
| . | 00226 | | STR | A•W(F+1) | 01170 | 15030 00211 | STORE DIFF. AZ2 |
| . | 00227 | | ENT | A•W(AZ+3) | 01171 | 11030 63074 | |
| . | 00230 | | STR | A•W(AZ+2) | 01172 | 15030 63073 | MOVE AZ3 |
| . | 00231 | | SUB | A•W(AZ) | 01173 | 21030 63071 | |
| . | 00232 | | STR | A•W(F+2) | 01174 | 15030 00212 | STORE DIFF. AZ3 |
| . | 00233 | | ENT | A•400 | 01175 | 11000 00400 | |
| . | 00234 | | STR | A•W(LAP) | 01176 | 15030 01326 | |
| . | 00235 | | ENT | B4•AAZ | 01177 | 12400 00214 | SPECIFY AZ A TABLE |
| . | 00236 | | ENT | B5•L(AZIMADD) | 01200 | 12510 63442 | SPECIFY AZIMUTH BUFFER |
| . | 00237 | | RJP | INTSUBR | 01201 | 65000 01336 | |
| . | 00240 | | ENT | A•W(EL) | 01202 | 11030 63075 | |
| . | 00241 | | SUB | A•W(EL+1) | 01203 | 21030 63076 | |
| . | 00242 | | STR | A•W(F) | 01204 | 15030 00210 | STORE DIFF OF EL0 |
| . | 00243 | | ENT | A•W(EL+1) | 01205 | 11030 63076 | |
| . | 00244 | | STR | A•W(EL)•APOS | 01206 | 15630 63075 | |
| . | 00245 | | SUB | A•200•SKIP | 01207 | 21100 00200 | |
| . | 00246 | | ADD | A•200 | 01210 | 20000 00200 | |
| . | 00247 | | STR | A•W(F+3) | 01211 | 15030 00213 | STORE ROUNDED EL1 |
| . | 00250 | | ENT | A•W(EL+2) | 01212 | 11030 63077 | |
| . | 00251 | | STR | A•W(EL+1) | 01213 | 15030 63076 | MOVE EL2 |
| . | 00252 | | SUB | A•W(EL) | 01214 | 21030 63075 | |
| . | 00253 | | STR | A•W(F+1) | 01215 | 15030 00211 | STORE DIFF EL2 |
| . | 00254 | | ENT | A•W(EL+3) | 01216 | 11030 63100 | |
| . | 00255 | | STR | A•W(EL+2) | 01217 | 15030 63077 | MOVE EL3 |
| . | 00256 | | SUB | A•W(EL) | 01220 | 21030 63075 | |
| . | 00257 | | STR | A•W(F+2) | 01221 | 15030 00212 | STORE DIFF EL3 |
| . | 00260 | | ENT | B4•AEL | 01222 | 12400 00445 | SPECIFY EL A TABLE |
| . | 00261 | | ENT | B5•L(ELEVADD) | 01223 | 12510 63443 | SPECIFY ELEVATION BUFFER |
| . | 00262 | | RJP | INTSUBR | 01224 | 65000 01336 | |
| . | 00263 | | ENT | A•W(R+1) | 01225 | 11030 01461 | |
| . | 00264 | | STR | A•W(R) | 01226 | 15030 01460 | |
| . | 00265 | | ADD | A•W(R+2) | 01227 | 20030 01462 | |
| . | 00266 | | ADD | A•1 | 01230 | 20000 00001 | |
| . | 00267 | | RSH | AQ•1 | 01231 | 03000 00001 | |
| . | 00270 | | ENT | B4•L(RANGEADD) | 01232 | 12410 63445 | |
| . | 00271 | | STR | A•W(B4) | 01233 | 15034 00000 | AVERAGE RANGE IN INTERRANGE |
| . | 00272 | | ENT | A•W(R+2) | 01234 | 11030 01462 | |

| CARDS | L1 | ID | LABEL | TA | STATEMENT | LOC | F | JKB | Y | NOTES |
|---|---|---|---|---|---|---|---|---|---|---|
| . | 00273 | | | | STR A*W(R+1) | 01235 | 15030 | | 01461 | |
| . | 00274 | | | | ENT A*W(CRANGE) | 01236 | 11030 | | 63057 | |
| . | 00275 | | | | STR A*W(R+2) | 01237 | 15030 | | 01462 | R VALUES MOVED |
| . | 00276 | | | | ENT A*W(RDOT) | 01240 | 11030 | | 01463 | |
| . | 00277 | | | | SUB A*W(RDOT+1) | 01241 | 21030 | | 01464 | |
| . | 00300 | | | | STR A*W(F) | 01242 | 15030 | | 00210 | STORE DIFFERENCE OF RDOTO |
| . | 00301 | | | | ENT Q*W(RDOT+1) | 01243 | 10030 | | 01464 | |
| . | 00302 | | | | STR Q*W(RDOT) | 01244 | 14030 | | 01463 | MOVE RDOTO |
| . | 00303 | | | | ADD Q*W(BIAS) | 01245 | 26030 | | 01335 | |
| . | 00304 | | | | STR Q*W(F+3) | 01246 | 14030 | | 00213 | STORE ROUNDED AND BIASED DOP1 |
| . | 00305 | | | | ENT A*W(RDOT+2) | 01247 | 11030 | | 01465 | |
| . | 00306 | | | | STR A*W(RDOT+1) | 01250 | 15030 | | 01464 | MOVE RDOT2 |
| . | 00307 | | | | SUB A*W(RDOT) | 01251 | 21030 | | 01463 | |
| . | 00310 | | | | STR A*W(F+1) | 01252 | 15030 | | 00211 | STORE DIF. RDOT2 |
| . | 00311 | | | | ENT Q*W(RANGEDOT) | 01253 | 10030 | | 63062 | |
| . | 00312 | | | | MUL W(RECC) | 01254 | 22030 | | 00057 | |
| . | 00313 | | | | RSH AQ*30D | 01255 | 03000 | | 00036 | B24 |
| . | 00314 | | | | SUB Q*W(UKS) | 01256 | 27030 | | 00056 | |
| . | 00315 | | | | MUL W(RANGEDOT) | 01257 | 22030 | | 63062 | |
| . | 00316 | | | | RSH AQ*24D | 01260 | 03000 | | 0003C | B24 |
| . | 00317 | | | | MUL W(CONVERSION) | 01261 | 22030 | | 00061 | |
| . | 00320 | | | | RSH AQ*26D | 01262 | 03000 | | 00032 | DOP3 BB CPS |
| . | 00321 | | | | STR Q*W(RDOT+2) | 01263 | 14030 | | 01465 | MOVE RDOT3 |
| . | 00322 | | | | SUB Q*W(RDOT) | 01264 | 27030 | | 01463 | |
| . | 00323 | | | | STR Q*W(F+2) | 01265 | 14030 | | 00212 | STOR DIF. RDOT3 |
| . | 00324 | | | | ENT B4*L(RANGEADD) | 01266 | 12410 | | 63445 | |
| . | 00325 | | | | ENT Q*W(B4) | 01267 | 10034 | | 00000 | |
| . | 00326 | | | | MUL W(RANGEUNIT) | 01270 | 22030 | | 01334 | |
| . | 00327 | | | | RSH AQ*10 | 01271 | 03000 | | 00010 | TIME B28 |
| . | 00330 | | | | MUL W(F+1) | 01272 | 22030 | | 00211 | |
| . | 00331 | | | | RSH AQ*28D | 01273 | 03000 | | 00034 | RANGE CORRECTION B8 |
| . | 00332 | | | | ADD Q*W(F+3) | 01274 | 26030 | | 00213 | |
| . | 00333 | | | | STR Q*W(F+3) | 01275 | 14030 | | 00213 | ADD TRANSIT TIME DOPPLER CHANG E |
| . | 00334 | | | | CL W(LAP) | 01276 | 16030 | | 01326 | |
| . | 00335 | | | | ENT B4*ADOP | 01277 | 12400 | | 00676 | SPECIFY DOPPLER A TABLE |
| . | 00336 | | | | ENT B5*L(DOPPADD) | 01300 | 12510 | | 63444 | SPECIFY DOPPLER BUFFER |
| . | 00337 | | | | RJP INTSUBR | 01301 | 65000 | | 01336 | |
| . | 00340 | | | | EXIT | 01302 | 61010 | | 01127 | |
| . | 00341 | | TEST1 | | ENT A*W(EL+3) | 01303 | 11030 | | 63100 | |
| . | 00342 | | | | STR A*W(EL+2) | 01304 | 15030 | | 63077 | |
| . | 00343 | | | | STR A*W(EL+1) | 01305 | 15030 | | 63076 | |
| . | 00344 | | | | STR A*W(EL) | 01306 | 15030 | | 63075 | |
| . | 00345 | | | | JP ENDEL+5 | 01307 | 61000 | | 01155 | |
| . | 00346 | | BOUNCE | | 0010431634 | 01310 | 00104 | | 31634 | DEC .0167827 OV ERSHOOT CONSTANT |
| . | 00347 | | TEST2 | | SUB A*W(AZMIN)*ANEG | 01311 | 21730 | | 01331 | |
| . | 00350 | | | | JP ENDAZ+1 | 01312 | 61000 | | 01136 | |
| . | 00351 | | | | ENT A*W(AZMIN) | 01313 | 11030 | | 01331 | |
| . | 00352 | | | | JP ENDAZ | 01314 | 61000 | | 01135 | |
| . | 00353 | | TEST3 | | ENT A*W(AZ+3) | 01315 | 11030 | | 63074 | |
| . | 00354 | | | | STR A*W(AZ+2) | 01316 | 15030 | | 63073 | |

| CARDS | L1 | ID | LABEL | TA | STATEMENT | LOC | F | JKB | Y | NOTES |
|---|---|---|---|---|---|---|---|---|---|---|
| . | 00355 | | | | STR A•W(AZ+1) | 01317 | 15 | 030 | 63072 | |
| . | 00356 | | | | STR A•W(AZ) | 01320 | 15 | 030 | 63071 | |
| . | 00357 | | | | JP ENDAZBOUNC+1 | 01321 | 61 | 000 | 01143 | |
| . | 00360 | | TEST5 | | SUB A•W(ELMIN)•ANEG | 01322 | 21 | 730 | 01327 | |
| . | 00361 | | | | JP ENDEL-1 | 01323 | 61 | 000 | 01147 | |
| . | 00362 | | | | ENT A•W(ELMIN) | 01324 | 11 | 030 | 01327 | |
| . | 00363 | | | | JP ENDEL | 01325 | 61 | 000 | 01150 | |
| . | 00364 | | LAP | | 0 | 01326 | 00 | 000 | 00000 | |
| . | 00365 | | ELMIN | | 7775341217 | 01327 | 77 | 753 | 41217 | DEC -.005827 |
| . | 00366 | | ELMAX | | 0200000000 | 01330 | 02 | 000 | 00000 | DEC .25827 |
| . | 00367 | | AZMIN | | 7534121727 | 01331 | 75 | 341 | 21727 | DEC -.32827 MINIMUM ALLOWABLE AZIM |
| . | 00370 | | AZMAX | | 1243656050 | 01332 | 12 | 436 | 56050 | DEC 1.32827 MAXIMUM ALLOWABLE AZIM |
| . | 00371 | | REVOLUTION | | 1000000000 | 01333 | 10 | 000 | 00000 | DEC 1827 |
| . | 00372 | | RANGEUNIT | | 0000006553 | 01334 | 00 | 000 | 06553 | DEC .00000005836 •1 USEC./2SEC. |
| . | 00373 | | BIAS | | 1334330200 | 01335 | 13 | 343 | 30200 | DEC 750000.5B8 DOPPLER BIAS AND ROUNDING |
| . | 00374 | | INTSUBR | | ENTRY | 01336 | 61 | 000 | 00000 | BUFFER LOC IN B5, A LOC IN B4 |
| . | 00375 | | | | ENT Q•W(F) | 01337 | 10 | 030 | 00210 | |
| . | 00376 | | | | MUL W(B4) | 01340 | 22 | 034 | 00000 | |
| . | 00377 | | | | RSH AQ•27D | 01341 | 03 | 000 | 00033 | |
| . | 00400 | | | | STR Q•W(FIRST) | 01342 | 14 | 030 | 00201 | |
| . | 00401 | | | | ENT Q•W(F+1) | 01343 | 10 | 030 | 00211 | |
| . | 00402 | | | | MUL W(1+B4) | 01344 | 22 | 034 | 00001 | |
| . | 00403 | | | | RSH AQ•27D | 01345 | 03 | 000 | 00033 | |
| . | 00404 | | | | ADD Q•W(FIRST) | 01346 | 26 | 030 | 00201 | |
| . | 00405 | | | | STR Q•W(FIRST) | 01347 | 14 | 030 | 00201 | |
| . | 00406 | | | | ENT Q•W(F+2) | 01350 | 10 | 030 | 00212 | |
| . | 00407 | | | | MUL W(2+B4) | 01351 | 22 | 034 | 00002 | |
| . | 00410 | | | | RSH AQ•27D | 01352 | 03 | 000 | 00033 | |
| . | 00411 | | | | ADD Q•W(FIRST) | 01353 | 26 | 030 | 00201 | FFIRST = A-1F-1+A1F1+A2F2 |
| . | 00412 | | | | STR Q•W(FIRST) | 01354 | 14 | 030 | 00201 | FIRST POINT COMPUTED |
| . | 00413 | | | | ENT B6•49D | 01355 | 12 | 600 | 00061 | SET UP LOOP |
| . | 00414 | | R5 | | ENT Q•W(F) | 01356 | 10 | 030 | 00210 | |
| . | 00415 | | | | MUL W(3+B4) | 01357 | 22 | 034 | 00003 | |
| . | 00416 | | | | RSH AQ•27D | 01360 | 03 | 000 | 00033 | |
| . | 00417 | | | | STR Q•W(SECOND) | 01361 | 14 | 030 | 00202 | |
| . | 00420 | | | | ENT Q•W(F+1) | 01362 | 10 | 030 | 00211 | |
| . | 00421 | | | | MUL W(4+B4) | 01363 | 22 | 034 | 00004 | |
| . | 00422 | | | | RSH AQ•27D | 01364 | 03 | 000 | 00033 | |
| . | 00423 | | | | ADD Q•W(SECOND) | 01365 | 26 | 030 | 00202 | |
| . | 00424 | | | | STR Q•W(SECOND) | 01366 | 14 | 030 | 00202 | |
| . | 00425 | | | | ENT Q•W(F+2) | 01367 | 10 | 030 | 00212 | |
| . | 00426 | | | | MUL W(5+B4) | 01370 | 22 | 034 | 00005 | |
| . | 00427 | | | | RSH AQ•27D | 01371 | 03 | 000 | 00033 | |
| . | 00430 | | | | ADD Q•W(SECOND) | 01372 | 26 | 030 | 00202 | FSEC = A-1F-1+A1F1+A2F2 |
| . | 00431 | | | | STR Q•W(SECOND) | 01373 | 14 | 030 | 00202 | SECOND POINT COMPUTED |

| CARDS | L1 ID LABEL | TA STATEMENT | LOC | F JKB Y | NOTES |
|---|---|---|---|---|---|
| . | 00432 | SUB Q•W(FIRST) | 01374 | 27030 00201 | |
| . | 00433 | MUL W(TENTH) | 01375 | 22030 01457 | |
| . | 00434 | RSH AQ•32D | 01376 | 03000 0004C | |
| . | 00435 | STR Q•W(JUNK) | 01377 | 14030 00200 | DIFFERENCE BETWEEN 4POINT INT. POINTS |
| . | 00436 | ENT A•W(F+3) | 01400 | 11030 00213 | |
| . | 00437 | ADD A•W(FIRST)•APOS | 01401 | 20630 00201 | |
| . | 00440 | ADD A•W(LAP) | 01402 | 20030 01326 | |
| . | 00441 | RSH AQ•8D | 01403 | 03000 00010 | |
| . | 00442 | STR A•W(B5) | 01404 | 15035 0000C | F0 LINEARLY INTERPOLATED |
| . | 00443 | LSH AQ•8D | 01405 | 07000 0001C | |
| . | 00444 | ADD A•W(JUNK) | 01406 | 20030 00200 | |
| . | 00445 | RSH AQ•8D | 01407 | 03000 00010 | |
| . | 00446 | STR A•W(1+B5) | 01410 | 15035 00001 | F1 LIN INT |
| . | 00447 | LSH AQ•8D | 01411 | 07000 0001C | |
| . | 00450 | ADD A•W(JUNK) | 01412 | 20030 00200 | |
| . | 00451 | RSH AQ•8D | 01413 | 03000 0001C | |
| . | 00452 | STR A•W(2+B5) | 01414 | 15035 00002 | F2 LIN INT |
| . | 00453 | LSH AQ•8D | 01415 | 07000 0001C | |
| . | 00454 | ADD A•W(JUNK) | 01416 | 20030 00200 | |
| . | 00455 | RSH AQ•8D | 01417 | 03000 0001C | |
| . | 00456 | STR A•W(3+B5) | 01420 | 15035 00003 | F3 LIN INT |
| . | 00457 | LSH AQ•8D | 01421 | 07000 0001C | |
| . | 00460 | ADD A•W(JUNK) | 01422 | 20030 00200 | |
| . | 00461 | RSH AQ•8D | 01423 | 03000 00010 | |
| . | 00462 | STR A•W(4+B5) | 01424 | 15035 00004 | F4 LIN INT |
| . | 00463 | LSH AQ•8D | 01425 | 07000 0001C | |
| . | 00464 | ADD A•W(JUNK) | 01426 | 20030 00200 | |
| . | 00465 | RSH AQ•8D | 01427 | 03000 0001C | |
| . | 00466 | STR A•W(5+B5) | 01430 | 15035 00005 | F5 LIN INT |
| . | 00467 | LSH AQ•8D | 01431 | 07000 0001C | |
| . | 00470 | ADD A•W(JUNK) | 01432 | 20030 00200 | |
| . | 00471 | RSH AQ•8D | 01433 | 03000 0001C | |
| . | 00472 | STR A•W(6+B5) | 01434 | 15035 00006 | F6 LIN INT |
| . | 00473 | LSH AQ•8D | 01435 | 07000 0001C | |
| . | 00474 | ADD A•W(JUNK) | 01436 | 20030 00200 | |
| . | 00475 | RSH AQ•8D | 01437 | 03000 0001C | |
| . | 00476 | STR A•W(7+B5) | 01440 | 15035 00007 | F7 LIN INT |
| . | 00477 | LSH AQ•8D | 01441 | 07000 0001C | |
| . | 00500 | ADD A•W(JUNK) | 01442 | 20030 00200 | |
| . | 00501 | RSH AQ•8D | 01443 | 03000 0001C | |
| . | 00502 | STR A•W(10+B5) | 01444 | 15035 0001C | F8 LIN INT |
| . | 00503 | LSH AQ•8D | 01445 | 07000 0001C | |
| . | 00504 | ADD A•W(JUNK) | 01446 | 20030 00200 | |
| . | 00505 | RSH AQ•8D | 01447 | 03000 00010 | |
| . | 00506 | STR A•W(11+B5) | 01450 | 15035 00011 | TEN VALUES LINEARLY INTERPOLATED |
| . | 00507 | ENT B4•3+B4 | 01451 | 12404 00003 | |
| . | 00510 | ENT B5•10D+B5 | 01452 | 12505 00012 | |
| . | 00511 | MOVE 1•SECOND•FIRST | 01453 | 10030 00202 | |
| | | | 01454 | 14030 00201 | |
| . | 00512 | BJP B6•R5 | 01455 | 72600 01356 | |
| . | 00513 | EXIT | 01456 | 61010 01336 | |

| CARDS | L1 | ID | LABEL | TA | STATEMENT | | LOC | F | JKB | Y | NOTES |
|---|---|---|---|---|---|---|---|---|---|---|---|
| . | 00514 | | TENTH | | 3146314631 | | 01457 | 31463 | | 14631 | |
| . | 00515 | | R | | RESERVE | 3* | 01460 | 00000 | | 00000 | |
| . | 00516 | | RDOT | | RESERVE | 3* | 01463 | 00000 | | 00000 | |
| . | 00517 | | | | RESERVE | 1 | 01466 | 00000 | | 00000 | |

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13. ABSTRACT

The Haystack antenna is pointed by means of a Univac 490 Computer. In the Pointing System program is incorporated an interpolation routines to provide pointing information 250 times a second. This report describes the interpolation routine.

DD FORM 1 JAN 64 1473

Security Classification

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